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Monetary Model of Ringgit Exchange

Khairizah Hj Abas[1], Zarinah Yusof [2], and Siti Muliana Samsi [3]
[1] Faculty of Economics and Administration, University Malaya, 50603,Kuala Lumpur, Malaysia
[2] Faculty of Economics and Administration, University Malaya, 50603,Kuala Lumpur, Malaysia
[3] Faculty of Economics and Administration, University Malaya, 50603,Kuala Lumpur, Malaysia

Abstract. This study re-examines the dynamic linkages between exchange rate and its monetary fundamentals namely, money, income and interest rate in a small emerging state of Malaysia. It investigates the short-run dynamics and long run relationships between ringgit exchange and its fundamental monetary variables. Based on the flexible price monetary framework, the model was tested via Johansen cointegration technique and vector error correction model using data set from 1980:Q1 to 2008:Q3. The findings suggest a strong evidence of long run relationship between exchange rate and the monetary fundamentals in Malaysia. Interestingly, further examination demonstrates that ringgit adjusts gradually to changes in money, income and interest rate, generally implying less volatile ringgit.

Keywords: monetary model of exchange rate, flexible price model, money, cointegration, vector error correction model

1. Introduction

Monetary models of exchange rate have been widely examined since the breakdown of pegged exchange rate system in the 1970s. The models explain that exchange rate moves to equilibrate to the changes in money, income and interest rate. There are two types of monetary models, the flexible-price monetary model (FPMM) developed by Frenkel (1976) and Bilson (1978) and sticky-price monetary model (SPMM) advanced by Dornbush (1976). Nevertheless both variants of the models produce the same long-run condition between the exchange rate and its fundamental variables (Makrydakis, 1998). MacDonald and Taylor (1991, 1994), Choudhry and Lawler (1997), Diamandis and Kouretas (1996), Makrydakis (1998), Miyakoshi (1999), MacDonald and Nagayasu (1998) and Lee Chin et al. (2007a, 2007b) found favourable evidence of the long run validity of monetary model of exchange rate. In recent study in Malaysia by Lee Chin et al. (2007b), examining different variants of the models, they further analyze the speed of the adjustments by dividing into pre and post crisis period applying data from 1980Q1 to 2006Q2. Unfortunately, they fail to find evidence of cointegration among the variables before the financial crisis for the flexible-price model. They found that exchange rate adjust 10% (sticky price model) in the pre-crisis and 57%-58% in the post-crisis and conclude ringgit reacted more rapidly after the crisis period.

This paper is motivated by the study of Lee Chin et al. (2007b) in response to provide more evidence on the monetary model of exchange rate from the flexible price variant. It is believed that the variables are cointegrated even when period pre crisis is considered. The discussion of this paper follows the following outline. Section 2, discusses data and methodology used in this study. Section 3 reports the empirical results. Finally, Section 4 concludes the findings.

2. Data and Methodology

2.1.Data

All data were compiled from International Financial Statistics, *International Monetary Funds* for all variables except for income for Malaysia was obtained from *Monthly Statistically Bulletin* published by the Central Bank of Malaysia. The data are quarterly spanning from 1980:Q1 to 2008:Q3. Exchange rates are RM/USD, the income variable is GDP with base year 2000, the broad money (M2) is a proxy for money supply and three-month Treasury bill rates are used as interest rates for both countries. All variable are natural logarithm except interest rate.

2.2.
Methodology

The monetary approach starts from the definition of the exchange rate as the relative price of two monies and model the relative price in terms of relative supply and demand for those monies. This model assumed that domestic goods prices are fully flexible. That is, if the domestic money supply increases by x percent, the domestic prices will rise immediately by x percent and domestic currency will depreciates by x percent. In the discrete time, monetary equilibrium in the domestic and foreign country respectively are given by,

$_{tttt}ikypm$ · · · · (1)

$^{******}_{tttt}iykpm_{tt}$ · · · · (2)

where *ypm*,, and *i* denote the log-level of the money supply, the price level, income and the level of the interest rate respectively, *k* and · are constant and asterisk denotes the foreign variables. The above models are transformed into a reduced equation in the flexible-price monetary approach as follows:

$_{ttttttt}iiyymme$ · · · · · · · · · · · · · · · · · · · $_{6543210}$ (3)

A rise in domestic (foreign) money supply is expected to cause the depreciation (appreciation) of the exchange rate. ($\beta_1 > 0$ and $\beta_2<0$), an increase in domestic (foreign) income will raise the demand for money and leading to the appreciation (depreciation) of the exchange rate ($\beta_3<0$, and $\beta_4>0$) and a rise in the domestic (foreign) interest rate reduces money demand and cause exchanges to depreciate (appreciation) ($\beta_5 > 0$ and $\beta_6 < 0$).

Cointegration analysis and vector error correction model (VECM) are employed to test the dynamics of the variables. It is important to run unit root tests on all the series to check for stationarity properties and choosing for the appropriate statistical technique. Many macroeconomics variables are not stationary in their level form and regression involving these series is dubious. Cointegration analysis is conducted on the difference series which assumes there always exist a linear combination of these variables that is stationary and a corresponding error correction modeling.

The estimation of the VECM offers evidence from the short-run relationship from the lagged difference variables and long-run dynamics from the error correction term. The estimating model of the short-run dynamic error correction model for ringgit can be expressed as follows:

$_{1407406*405404*4034021401}22$ ·

· · · · · · · · $_{titcciiitiiitiiitiiitiiitiiit}ECTrryymmee$ · (4)

ECT is the error correction term. To capture the effects of seasonality on the variables, a set of quarterly centered dummy variables D1, D2, D3 is introduced in the model.

3.
Findings

3.1 Cointegration Test

The ADF test and PP test statistics suggest that all the series are I(0) in first difference (Table 1). In short, the findings from the unit root tests suggest that all the series are integrated in the same order, I(1). Thus, cointegration analysis is appropriately model. The cointegration test (Johansen and Juselius, 1990) suggests that there is a long run relationship between exchange rate and its determinants. The test used lag length 4 and it was chosen based on the Akaike Information Criterion (AIC). The result of using optimal lag structure for VAR model is summarized in Table 2. Both maximum eigenvalues ($_{\max}\bullet$) and ($_{trace}\bullet$) statistics rejects the hypotheses that these are zero cointegrating vectors. The detection of at least one or more co-integrating vectors among the exchange rate and its monetary fundamentals can be taken as evidence of supporting the unrestricted exchange rate monetary model as the long run equilibrium theory in ringgit per US dollar. This finding contradicts with Lee Chin et al. (2007b) in their analysis of pre-crisis period.

3.2 Cointegrating Vector, Monetary Restrictions and Test of Exclusion Restriction

The estimated parameters of cointegrating vectors (β_s) are reported in Table 3. Normalizing the equations on the exchange rate allows us to directly compare the hypothesized values of equation (4). None of these equations has all the signs that are consistent with the theory. This is not important as the cointegrating regression cannot be directly interpretable as structural c

The predictions of the flexible price monetary model imply that the general unrestricted form is always equivalent to the reduced form. However, this is true only when the imposed restrictions are valid. Table 4 reports the test of some commons, monetary restrictions. The most important of these parameter restrictions is the existence of proportionality between exchange rate and relative monies (H_1), equal and opposite coefficient on relative income (H_2) and interest rate (H_3). The estimates report the value of likelihood ratio χ_2 statistics. The monetary restrictions are not rejected for H_3 at 5 percent significant level. However, the restrictions are overwhelmingly rejected in all the others cases at the conventional significance level.

Table 5 shows the results of exclusion restrictions on exchange rate, money supply, output and interest rate. In each case, the hypothesis that exchange rate does not enter into the co-integrating relationship is easily rejected at least at 10% significance level. Thus, none these variables is excluded in forming the co-integrating relationship.

3.3 Vector Error Correction Model

The results from VECM are presented in Table 6. The estimation There is little evidence from the short-run impacts but from the statistically significant error correction term and correctly signed, this study suggests that exchange rates are linking closely to money, income and interest rates. In order words, there is valid explanation for monetary model of exchange rate. For parsimony, parsimonious error correction model is presented in Table 7 by dropping the most insignificant variables. The model is presented below.

$$\Delta e_t = -2.23 + 0.06\Delta e_{t-1} - 1.36\Delta e_{t-2} + 0.08\Delta m_{t-1} + 0.06\Delta m_{t-3} + 0.69\Delta m^{*}{}_{t-1} + 0.70\Delta m^{*}{}_{t-2} - 0.32\Delta m^{*}{}_{t-3}$$
$$(0.00)\ (0.33)\qquad (0.029)\qquad (0.253)\qquad (0.403)\qquad (0.07)\qquad (0.74)\qquad (0.34)$$

$$+0.16\Delta y_{t-1} - 0.26\Delta y_{t-3} + 0.34\Delta y^{*} - 0.22\Delta y^{*} - 0.02\Delta r_{t-1} + 0.12\Delta r_{t-2} - 0.56\Delta r^{*}{}_{t-1} - 0.002\Delta r^{*}{}_{t-2}$$
$$(0.23)\qquad (0.04)\qquad (0.42)\qquad (0.54)\qquad (0.00)\qquad (0.98)\qquad (0.87)\qquad (0.59)$$

$$0.03D1 + 0.04D2 + 0.02D3 + 0.19y909798 + 0.03ECT_{t-1} - 0.09ECT_{t-2}$$
$$(0.03)\quad (0.01)\quad (0.04)\quad (0.00)\qquad (0.107)\qquad (0.00)$$
$$\chi^2_{SC}[4] = [.136] \qquad \chi^2_{N}[1] = [0.185] \qquad \chi^2_{FF}[2] = [0.007] \qquad \chi^2_{H}[1] = [.185]$$

All the estimated money supply and income have the expected signs. US interest rate also has the expected sign. The positive sign of the domestic money supply indicate that an increase in the money supply will lead to a depreciation of the ringgit. Likewise, negative sign of the US money supply will lead to appreciation of the ringgit as money increases. For the negative sign of the domestic income, an increase in the real income leads to a rise in the money demand and hence, the appreciation of the ringgit exchange. On the other hand, the positive sign of the US income shows that when US income rises ringgit depreciates. The negative US interest rate will reduce its money demand and causes ringgit to appreciate.

The error-correction term from the parsimonious model is of the correct sign and highly significant for ECT_{t-2}. This suggests that exchange rate responds to the error correction term (ECT) by moving to reduce the disequilibrium with the speed of adjustment 9%. The response is much smaller compared to Lee Chin (2007b) where they found it to be at 57% and 58% in the post crisis period. Exchange rate only adjusts gradually, 10% (sticky price model), in the pre-crisis period. But if a full sample is considered which incorporated the financial crisis period, the speed of the adjustment is smaller. For country like Malaysia, the adjustment is acceptable and plausible when considering that ringgit is relatively stable.

Generally, not all short run parameters are consistent with the theory and expected sign and this suggest weak short run dynamic linkages. Estimate with the PECM model, supports the presence of one significant error correction term and establishes a single monetary exchange rate model. Thus, it verifies that monetary model can be use in modeling the ringgit exchange rate and the exchange rate is affected by the monetary fundamentals in the long run. The results are screened through a battery of diagnostic tests, namely serial correlation, heteroscedasticity, normality and functional form. The diagnostic tests are satisfactory. The residual is white noise. The selection of parsimonious error correction model for Malaysia is chosen based on R_2 and high value of Akaike Info Criterion (AIC).

4. Conclusion

This study found that all the macroeconomic variables are correlated. The presence of cointegrated variables suggests that ringgit exchange change with changes in money, income and interest rate. Therefore, the behavior of the monetary fundamentals needs to be watched closely in order to successfully predict exchange rate. This is important particularly as an open emerging economy, Malaysia is closely linked to international linkages through trade and financial markets. Malaysia is an export-driven country and received high inflow of capital from the world countries. Any erratic changes come from other factors outside the model. This is evidence from the financial crisis in 1997 which was triggered by the unstable Thai Baht. The finding demonstrates that exchange rate variable adjust slowly to the disequilibrium to revert back to the system. The adjustment is smaller than found in the past studies in Malaysia. The validity of flexible exchange rate model is justified. Overall results are consistent with those presented by Rapach and Wohar (2001), Makrydakis (1998) and Karfakis (2003).

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Table 1: Unit Roots Test

Note: [a], [b], and [c] denotes for 1%, 5% and 10% significant level respectively, τ_{μ}, τ_{τ} and $Z(\tau_{\mu})$, $Z(\tau_{\tau})$ are the test statistics allowing for constant without trend and constant with trend respectively for ADF and PP test. Reported numbers in parentheses indicate appropriate lag length used in this test. For ADF optimal lag length was chosen by Akaike Information Criterion and PP was chosen automatically by Newey- West Bandwidth.

	Augmented Dickey-Fuller (ADF)		Phillips Perron (PP)	
	τ_{μ}	τ_{τ}	$z(\tau_{\mu})$	$Z(\tau_{\tau}$
		Levels		
e	-1.303[0]	-2.002[0]	-1.341[2]	-2.101[1]
m2	-0.005[1]	-1.578[1}	-0.348[6]	-1.783[6]
y	-0.391[6]	-1.563[6]	-0.476[11]	-2.971[10]
r	-1.913[0]	-2.268[0]	-1.9752[1]	-2.329[1]
*m2**	-0.393[6]	-2.9435[6]	-1.688[7]	-2.376[7]
*Y**	1.196[2]	-2.315[2]	-0.3474[5]	-8.388[3]
*r**	-1.610[1]	-2.469[2]	-2.321[4]	-3.065[2]
		First-differences		
Δe	-10.004[0][a]	-9.987[0][a]	-10.012[3][a]	-9.993[3][a]
$\Delta m2$	-9.007[0][a]	-8.964[0][a]	-9.104[5][a]	-9.063[5][a]
Δy	-4.596[5][a]	-4.577[5][a]	-12.563[11][a]	-12.497[11][a]
Δr	-10.165[0][a]	-10.135[0][a]	-10.211[3][a]	-10.183[3][a]
$\Delta m2^*$	-3.416[2][b]	-3.478[2][b]	-3.416[2][b]	3.478[2][b]
Δy^*	-5.791[1][a]	-4.444[2][a]	-8.387[3][a]	-8.374[3][a]
Δr^*	-9.073[3][a]	-9.013[3][a]	-8.389[3][a]	-8.376[3][a]

Table 3: Estimated Cointegrating Vectors

e	*m2*	*m2**	*y*	*Y**	*r*	*r**	CONST
1	4.230	-1.197	-6.799	-4.353	0.499	-0.410	72.331
1	-2.590	-0.755	5.780	2.075	0.788	0.581	-45.971

Table 5: Test of Exclusion Restrictions

	MALAYSIA
H_8: β_0=0	17.343[0.00]
H_9: β_1= β_2 =0	34.698[0.00]
H_{10}: β_3= β_4 =0	32.337[0.00]
H_{11}: β_5= β_6 =0	36.330[0.00]

Note: H_8 to H_{11} denote the hypotheses summarized testing. The number not in parentheses are χ^2 statistics wit degree of freedom equal r x k, where r denotes the number of cointegrating vectors and k is the number of restrictions. The number in parentheses is marginal significant level.

Table 4: Test of Some Common Monetary Restrictions

	MALAYSIA
H_1: $\beta_0 = \beta_1 = -\beta_2$	9.497[0.05]
H_2: $\beta_3 + \beta_4 = 0$	13.414[0.00]
H_3: $\beta_5 + \beta_6 = 0$	3.510[0.17]
H_4: $H_1 \cap H_2$	40.294[0.00]
H_5: $H_1 \cap H_3$	13.339[0.04]
H_6: $H_2 \cap H_3$	36.459[0.00]
H_7: $H_1 \cap H_2 \cap H_3$	49.599[0.00]

Note: H_1 to H7 denote the hypotheses testing. The number not in parentheses are χ^2 statistics wit degree of freedom equal r x k, where r denotes the number of cointegrating vectors and k is the number of restrictions. The number in parentheses is marginal significant level.

Table 2: Cointegration Test

$[e, m2, m2^*, y, y^*, r\ r^*]$

Hypothesis		$K = 4$		Critical Values			
				Λmax		Trace	
H_0	H_1	λmax	Trace	5%	10%	5%	10%
r = 0	r > 0	66.6272*	183.0706*	45.6300	42.70	124.62	119.68
r ≤ 1	r > 1	59.3818*	116.4434*	39.83	36.84	95.87	92.40
r ≤ 2	r > 2	25.0352	57.0616	33.64	31.02	70.49	66.23
r ≤ 3	r > 3	19.3457	32.0263	27.42	24.99	48.88	45.70
r ≤ 4	r > 4	8.6583	12.6806	21.12	19.02	31.54	28.78
r ≤ 5	r > 5	4.0041	4.0223	14.88	12.98	17.86	15.75
r ≤ 6	r = 7	.018131	.018131	8.07	6.50	8.09	6.5

Notes: * (**) denotes rejection of the hypothesis at the 10%(5%) level,Max-eigenvalue test indicates 2 cointegrating equation(s) at the 10% level, Trace test indicates 2 cointegrating equation(s) at both 10%

Table 6: VECM for Ringgit Malaysia / US Dollar

Dependent variable is Δe
111 observations used for estimation from 1981Q1 to 2008Q3

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
INTP	-2.1619	.55468	-3.8976[.000]
Δe(-1)	.054434	.063749	.85388[.396]
Δe(-2)	-.13393	.064780	-2.0675[.042]
Δe(-3)	-.10594	.069836	-1.5169[.133]
Δm(-1)	.074557	.075087	.99294[.324]
Δm(-2)	.037379	.075492	.49513[.622]
Δm(-3)	.063426	.074484	.85154[.397]
Δm*(-1)	.59437	.41076	1.4470[.152]
Δm*(-2)	.55670	.41030	1.3568[.179]
Δm*(-3)	-.48699	.38237	-1.2736[.206]
Δy(-1)	.10848	.14289	.75920[.450]
Δy(-2)	-.075388	.13542	-.55670[.579]
Δy(-3)	-.26474	.13304	-1.9900[.050]
Δy*(-1)	-.089040	.49910	-.17840[.859]
Δy*(-2)	.64188	.47083	1.3633[.176]
Δy*(-3)	.10565	.42592	.24805[.805]
Δr(-1)	-.015095	.0047018	-3.2106[.002]
Δr(-2)	.0012373	.0048570	.25476[.800]
Δr(-3)	.0029801	.0047458	.62794[.532]
Δr*(-1)	-.0031540	.0043107	-.73167[.466]
Δr*(-2)	-.0027650	.0045568	-.60680[.546]
Δr*(-3)	-.0051199	.0046774	-1.0946[.277]
SC1	.023638	.012113	1.9514[.054]
SC2	.034435	.016449	2.0935[.039]
SC3	.013187	.012489	1.0559[.294]
Y909798	.19466	.013430	14.4946[.000]
ECT1(-1)	.041877	.023343	1.7940[.076]
ECT2(-1)	-.082583	.023342	-3.5379[.001]

R-Squared	.76135	R-Bar-Squared	.68372
S.E. of Regression	.023343	F-stat. F(27, 83)	9.8073[.000]
Mean of Dependent Variable	.0039913	S.D. of Dependent Variable	.041506
Residual Sum of Squares	.045225	Equation Log-likelihood	275.7107
Akaike Info. Criterion	247.7107	Schwarz Bayesian Criterion	209.7773
DW-statistic	1.7737		

Serial Correlation	$\chi^2(4)$=4.1510[.386]	F(4, 79)=.76727[.550]
Functional Form	$\chi^2(1)$=7.7590[.005]	F(1, 82)=6.1627[.015]
Normality	$\chi^2(2)$=5.7449[.057]	Not applicable
Heteroscedasticity	$\chi^2(1)$=2.8009[.094]	F(1, 109)= 2.8216[.096]

Table 7: PECM Ringgit Malaysia / US Dollar

Dependent variable is DLRM
111 observations used for estimation from 1981Q1 to 2008Q3

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
INTP	-2.2333	.47336	-4.7180[.000]
Δe(-1)	.059210	.060325	.98152[.329]
Δe(-2)	-.13625	.061580	-2.2125[.029]
Δm(-1)	.082509	.071640	1.1517[.253]
Δm(-3)	.060775	.072270	.84095[.403]
Δm*(-1)	.68635	.37141	1.8480[.068]
Δm*(-2)	.70061	.38769	1.8071[.074]
Δm*(-3)	-.32465	.33648	-.96484[.337]
Δy(-1)	.16060	.13451	1.1940[.236]
Δy(-3)	-.26153	.12756	-2.0503[.043]
Δy*(-2)	.33967	.42160	.80567[.423]
Δy*(-3)	-.21609	.35041	-.61667[.539]
Δr(-1)	-.017335	.0043284	-4.0050[.000]
Δr(-3)	.1078E-3	.0043562	.024753[.980]
Δr*(-1)	-.5636E-3	.0033987	-.16584[.869]
Δr*(-2)	-.0021956	.0040848	-.53751[.592]
SC1	.025281	.011637	2.1725[.032]
SC2	.041581	.015423	2.6961[.008]
SC3	.018493	.0090623	2.0406[.044]
Y909798	.18980	.012872	14.7453[.000]
ECM14(-1)	.028383	.017443	1.6272[.107]
ECM24(-1)	-.089129	.020008	-4.4547[.000]

R-Squared	.74749	R-Bar-Squared	.68791
S.E. of Regression	.023188	F-stat. F(21, 89)	12.5458[.000]
Mean of Dependent Variable	.0039913	S.D. of Dependent Variable	.041506
Residual Sum of Squares	.047852	Equation Log-likelihood	272.5764
Akaike Info. Criterion	250.5764	Schwarz Bayesian Criterion	220.7716
DW-statistic	1.7503		

Diagnostic Tests

Serial Correlation	$\chi^2(4)$= 6.9984[.136]	;(4, 85)= 1.4299[.231]
Functional Form	$\chi^2(1)$= 7.2700[.007]	;(1, 88)= 6.1676[.015]
Normality	$\chi^2(2)$= 3.3711[.185]	;
Heteroscedasticity	$\chi^2(1)$= 1.7537[.185]	;(1, 109)= 1.7498[.189]